



## ANALYSIS OF RELATIONSHIP BETWEEN OCULOMOTOR AND PSEUDOSEIZURE ACTIVITY IN EEG EXAMINATIONS OF AVIATION PERSONNEL

Jan S. MISZCZAK<sup>1</sup>, Stanisław DEC<sup>1</sup>, Ewa ZALEWSKA<sup>2</sup>

<sup>1</sup>Military Institute of Aviation Medicine, Warsaw, Poland

<sup>2</sup>Nalęcz Institute of Biocybernetics and Biomedical Engineering, Warsaw, Poland

**Source of support:** Own sources

**Author's address:** J. Miszczak, Military Institute of Aviation Medicine, Krasińskiego 54/56 str., 01-755 Warsaw, Poland, e-mail: jmiszczak@wiml.waw.pl

**Introduction:** Electrooculographic (EOG) activity recorded simultaneously with the EEG signal is the most common artifact which may be eliminated from EEG records by special algorithms applied in the recording systems. The objective of this study was to identify potential relationships between the activity caused by involuntary eye movement and the spontaneous activity of the brain. A hypothesis was proposed with regard to a potential relationship between interoceptive (central) and exteroceptive (peripheral) mechanism of EOG activity and pseudoseizure episodes in EEG records of healthy subjects.

**Methods:** EEG, VEOG (vertical electrooculographic) and HEOG (horizontal electrooculographic) activity was recorded using a Neuroscan 4.3 system for neurophysiological examination with 1 kHz sampling frequency and 16-bit amplitude resolution. The records were made in line with the recommendation of the International Federation of Clinical Neurophysiology. The study group consisted of 30 healthy subjects aged 24-32 years. A total of 10 records with EOG artifacts were selected for the analysis. The signals were analyzed in the bands of 0.1-4 Hz, 4-8 Hz, 8-14 Hz, and 0.1-70 Hz using FFT, Intra-Class Correlation coefficients and coherence ratios.

**Results:** The results showed a significant variability of the amplitude and frequency of the episodes of EOG activity simultaneous to EEG oscillations in various areas of the brain. The highest impact of EOG on the EEG record was observed in the frontotemporal region. The coherence ratios for signals recorded in the mediotemporal region was 0.56-0.67 (delta) and 0.8-0.95 (theta) compared to <0.99 in the frontal region. Simultaneous EOG oscillations and pseudoseizure-type EEG activity were observed in 3 records.

**Figures:** 11 • **References:** 23 • **Full-text PDF:** <http://www.pjamp.com> • **Copyright** © 2014 Polish Aviation Medicine Society, ul. Krasińskiego 54/56, 01-755 Warsaw, license WIML • **Indexation:** Index Copernicus, Polish Ministry of Science and Higher Education

**Discussion:** The characteristics of oscillations of bioelectrical activity in various regions of the brain correlated to EOG activity in records taken with subjects' eyes open is different than in records taken with subjects' eyes being closed. The EEG records are indicative of a relationship between the central and peripheral neuronal mechanism of eye movements and the brain activity in various frequency bands. The results are suggestive of a potential impact of oculomotor activity on the recorded EEG oscillations. Therefore, interpretation of generalized oscillation episodes in healthy subjects requires the analysis of the morphology and dynamics of oscillations as well as of the simultaneous EOG activity.

**Conclusions:** Differentiation of pseudoseizure and seizure episodes requires oculomotor activity being recorded using an extended protocol with eyes both open and closed in order to verify the impact of oculomotor activity on EEG records.

**Keywords:** EEG, oculomotor activity, aviation medicine, VEOG, HEOG

## INTRODUCTION

Electroencephalography plays a very important role in qualification of candidates for aviation-related professions as it facilitates detection of CNS reactivity and cognitive function disorders that cannot be detected even using the most advanced neuroimaging techniques. Electroencephalography was first used in aviation medicine in the 1950s. [2,3,4,10,14,16,17]. Advances in the technique contributed to definition of stricter diagnostic criteria and thus to the increased relevance of the method.

One of the most important uses of EEG in aviation medicine is the screening for potential predispositions to seizure activity and transient loss of consciousness in candidates for aviation jobs. These phenomena are considered exclusion criteria in the qualification procedure. Differentiation of seizure activity and pseudoseizure activity in the EEG records of healthy subjects is one of the most important issues that still require more detailed studies [5,7,9,18,20,21,22].

In our studies, generalized paroxysmal activity (discharges) related only to short or long episodes of polymorphic activity of variable amplitude and frequency. In EEG, this type of activity is described as monorhythmic or mixed type and referred to as pseudoseizure activity. Episodes of paroxysmal activity identified as epileptogenic in origin, or featuring spikes, multispikes, sharp waves, and spike-and-wave complexes were not taken into account.

Our previous studies [18] revealed dissimilar characteristics of pseudoseizure activity recorded in healthy subjects and seizure activity in epileptic

patients. Differences were also observed in pre- and post-stimulus activity patterns. This suggests that these activities were generated by different mechanisms. The difficulty in differentiation between both types of activities is also due to the potential impact of extracerebral activity, e.g. EOG activity, on the EEG signal, which interferes with the analysis.

EEG signals are disturbed by signals classified as either biological or technical artifacts, including heart activity, ocular movements, muscle activity or signals from the environment [5,8,11,15,19,23]. Both biological and technical artifacts are eliminated from the record by means of advanced processing methods. However, as opposed to technical artifacts, biological artifacts may be of certain importance and provide diagnostic information.

The eyeball movement signal is very important in polysomnographic examinations as an indicator of individual phases of sleep [1]. In standard EEG records, EOG activity may be of importance for the assessment of wakefulness and sleepiness. Eyelid flutter observed in frontal leads may be associated with intellectual activity. Despite the potential usefulness of these signals and their impact on the EEG record, they are usually eliminated using automated EEG analysis methods [6,12,13,19].

The blinking reflex is associated with retinal function. During adaptation to darkness, the resting potential achieves the minimum value ("off") after several minutes. When the light is turned on, the potential increases ("on") and subsequently falls as the retina adapts to the light level.

Another type of artifacts is the eyelid flutter. Initially, it was referred to as Kappa waves. Eyelid flutter sometimes occurs during intellectual activities. They are contained within the theta (4-7 Hz) or alpha (8-13 Hz) bands. Artifacts of this type are commonly observed upon photostimulation.

In our study, we focused on the electrooculographic activity recorded in the EEG examinations. The eyeball is a dipole characterized by a positive potential of the posterior wall and a negative potential of the anterior wall. EOG artifacts are associated with the recording of the difference in potentials between the cornea and retina; they are characterized by high amplitude as compared to the EEG signal. Even slight eyeball movements are captured in the record acquired using the frontal leads. Upon gaze fixation, EOG potentials are not recorded. Opening the eyes induces a negative potential at Fp1 and Fp2; horizontal movement is observed by F7 and F8. Eyeballs moving left – positive potential at F7, negative potential at F8; opposite for eyeballs moving right. Anatomical projection of pathways associated with oculomotor activity including muscle function is presented in Fig. 1. Myogenic origin is predominant in case of peripheral artifacts, while neuronal activity is mainly responsible for central motor excitations observed in the image.

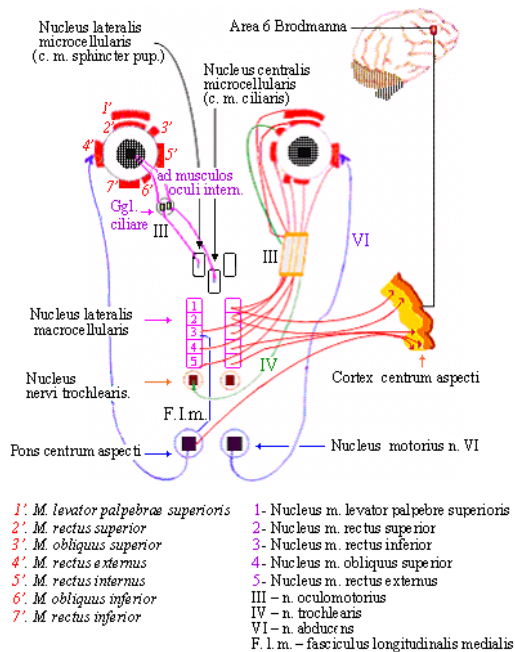
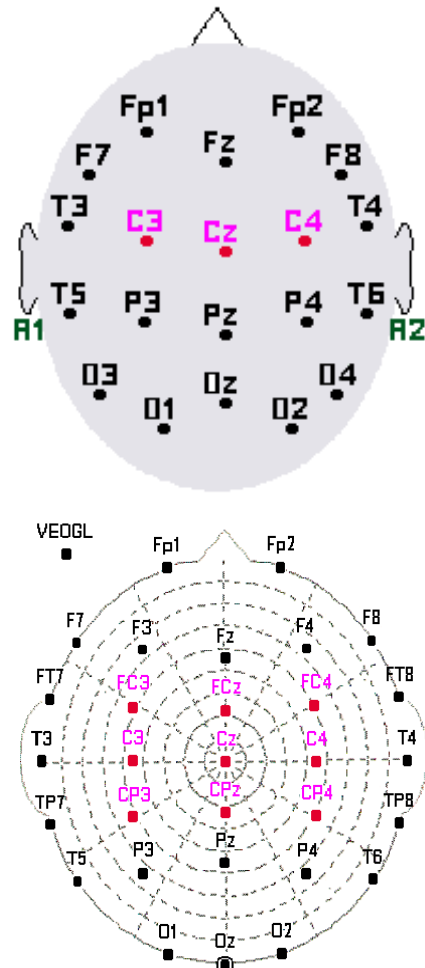


Fig. 1. Anatomical pathways of eye movements including muscles involved.

The complexity of the process requires a special signal-recording procedure. Selection of the reference electrode is an important element. Most commonly used electrodes are shown in Fig.2.



- CAR (Common Aver Reference)
- LAR (Local Aver Reference)
- A1, A2 (Ear electrodes)
- SOURCE (Source electrode according to Hjorth)
- IND (Independent electrode)

Fig. 2. Reference electrodes.

Location of the reference electrode should be taken into account when interpreting the EOG signals; for example, the spectral analysis requires an average electrode. Fig. 3. presents a spectrum of an oculographic artifact recorded during a pseudo-seizure activity with eyes open. Signals from frontal and middle-region leads (F3, F4, C3, C4) feature peaks corresponding to photic reaction and eyeball movement while the signals from occipitoparietal leads correspond to photic reaction only.

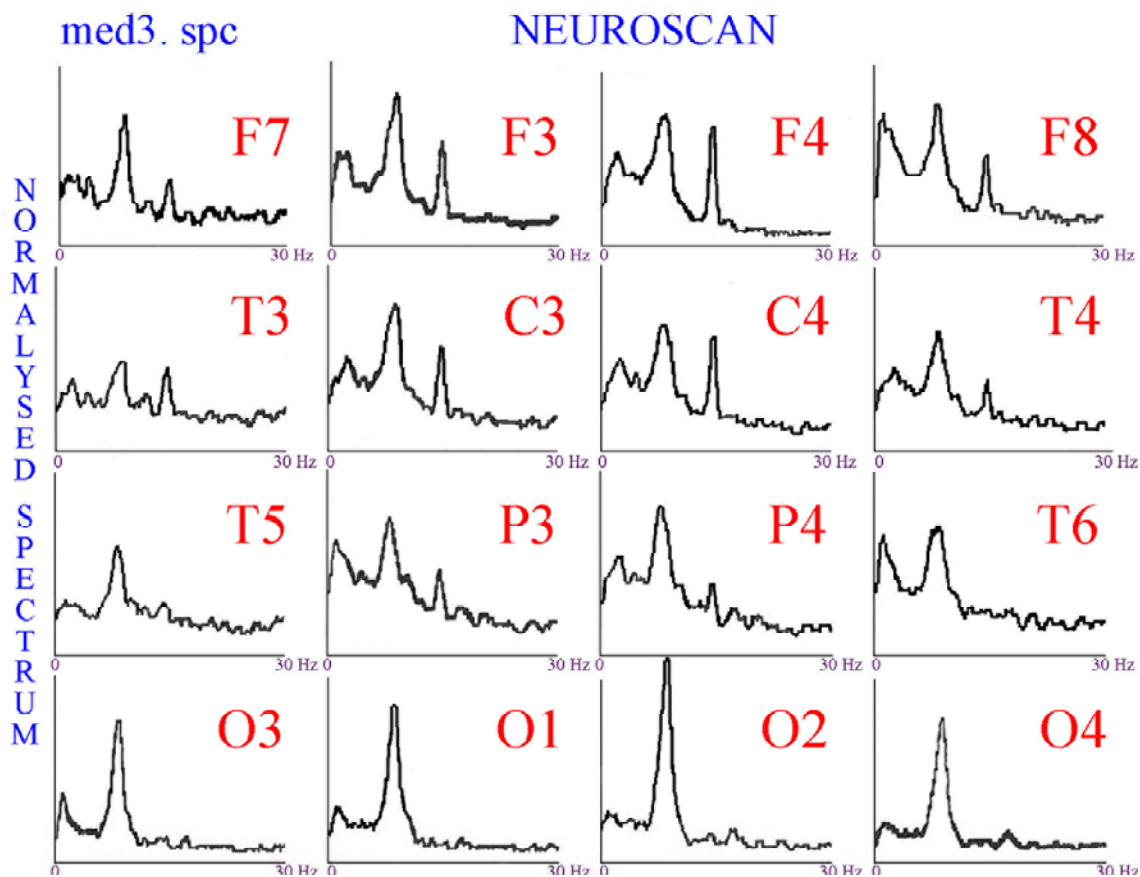


Fig. 3. Spectrum of oculographic artifacts recorded during a pseudo-seizure.

The EOG signals are recorded simultaneously to the EEG record as shown in Fig. 4. The high-amplitude HEOG activity is also seen in bipolar interhemispheric leads. This is suggestive of the involvement of the midline structures. Other artifacts including blinking and flutter also occur. In this study, the reference electrode was a GFP electrode.

Both HEOG and VEOG must be recorded in order to assess whether the recorded activity is associated with ocular movement. The cerebral function associated with the vertical movement is due to blinking and is of slow-wave character. EOG recording facilitates differentiation of artifacts and slow waves (delta). Oculomotor activity is recorded mainly from Fp1 and Fp2 leads while the slow delta waves are also recorded in the posterior brain regions. Frontal intermittent rhythmic delta activity (FIRDA) is sometimes accounted for seizure activity, possibly leading to false positive diagnoses [12].

The objective of this study was to analyze potential relationships between the spontaneous and involuntary eye movements and the activity of the brain. A hypothesis was proposed with re-

gard to a potential relationship between interoceptive (central) and exteroceptive (peripheral) mechanism of EOG activity and pseudoseizure episodes in EEG records of healthy subjects.

## METHODS

Examinations were conducted in the joint Centre for Integrated Structural and Functional Studies of the Central Nervous System CNSlab of the Nałęcz Institute of Biocybernetics and Biomedical Engineering and the Military Institute of Aviation Medicine.

The study group consisted of 30 healthy subjects aged 24-32 years. EEG with EOG artifacts were analyzed in groups divided according to the duration of artifacts: group A (N=10) with artifact durations of  $T = 0.7-1.0$  s and group B (N=10) with artifact durations of  $T = 2.8-3.2$  s. Each patient taking part in the study was informed with regard to the purpose and course of the study and provided written consent for participation.

EEG, VEOG, HEOG, ECG and respiratory activity signals were recorded using a Neuroscan 4.3 system for neurophysiological examination with

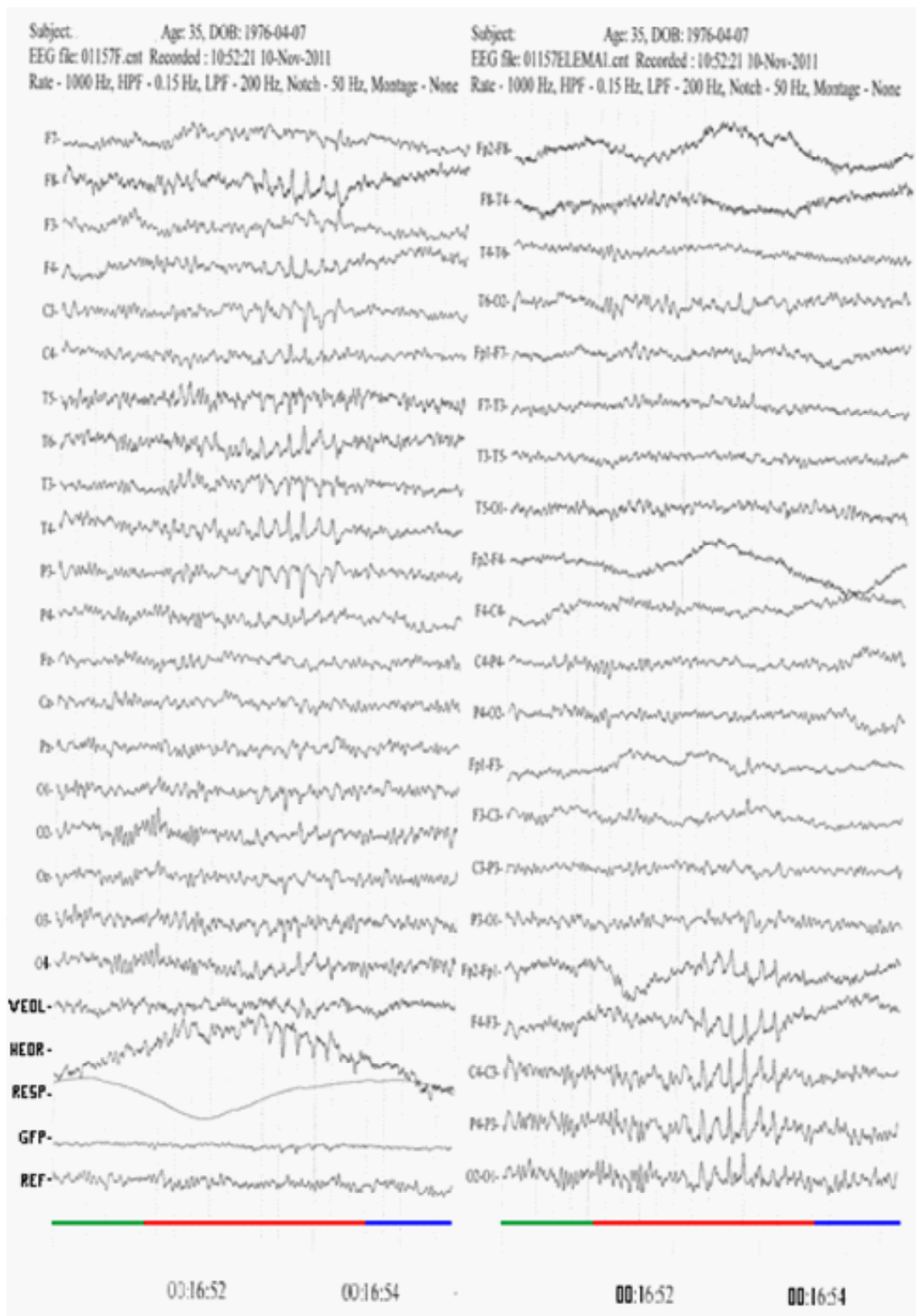


Fig. 4. VEOG and HEOG oculomotor signals recorded simultaneously with EEG. The red line on the bottom indicates the periods of artifacts.

1 kHz sampling frequency and 16 bit amplitude resolution. The system was additionally equipped with a video-recording capability allowing patients' behavior being monitored during the examination. The videorecording was synchronized with the EEG record.

EEG records were conducted while resting with eyes open. Recording fragments selected for the analysis featured oculomotor activity and a segment preceding this activity as a reference signal. The selected fragments were filtered in the frequency bands of 0.1-4 Hz, 4-8 Hz, 8-12 Hz, 0.1-70 Hz, and analyzed by means of FFT analysis (groups A and B) as well as by means of Intra-Class Correlation coefficients (groups A and B) and coherence ratios (group B).

## RESULTS

Example EOG records are shown in Fig. 5. (Group A). VEOG and HEOG activities recorded simultaneously were either characterized by similar graphical elements or were symmetrical in either channel.

Fig. 6. presents an example record of oculographic (HEOG, VEOG) and EEG activity. Marked in red is a fragment of the record (1 s) featuring biocular motor activity selected for QEEG analysis. Marked in blue is a fragment of the resting pattern (2.2 s) selected as the reference signal.

Components of the EEG signal associated with ocular movement within the delta (0.1-4Hz) and alpha (8-14 Hz) frequency bands are shown in Fig. 6a-c.

Comparison of spectral analyses of these signals to those of the resting (reference) signals is shown in Fig. 7. The histogram compares the strength of the EEG signals in frontal, middle and parietal leads as calculated by means of Intra Class Correlation analysis (total power in the 0.1-70 Hz band).

In the frontal region (Fig. 7a.) of the left hemisphere, the power of the EEG signal in the entire band (0.1-70 Hz) and in the alpha band (8-14 Hz)

was ca. 50% lower than in the remaining regions. The power of the EEG signal in the (0.1-4 Hz) band in the frontal region of the left hemisphere is similar to that in the remaining regions.

In the middle region (Fig. 7b.), asymmetry of EEG signal power (up to 50%) is observed in all frequency bands – predominance of right parietal region and left posterotemporal region is observed during the short episode of oculographic activity.

In the occipital leads, the signal power is higher on the left. As shown by the results of the analysis, oculomotor activity is associated with left-sided lateralization of EEG activity

The chart in Fig. 7d. shows the average values of power of the EEG signal recorded from 22 leads in the frequency bands of 0.1-4 Hz, 8-14 Hz, and 0.1-70 Hz (total). The highest values of > 55% were observed in the 0.1-4 Hz band. For higher frequencies, the signal power (8-14 and 0.1-70 Hz) does not exceed 50%. The lowest values were measured for the 0.1-70 Hz band. The significant diversity in average signal power in the entire frequency band as well as in the individual bands may be due to the short duration of the recorded episode ( $T < 1$  s) and to its presence in the frontal and middle region with a discrete predominance on the left. All subjects in the study group ( $N = 10$ ) were right-handed (random selection).

Fig. 8. (Group B) presents another type of oculomotor activity with high-amplitude oscillations.

Marked in red is a fragment of the EEG record ( $T = 3.20$  s) for spontaneous, biocular movements (blinking) selected for QEEG analysis. Marked in blue is a fragment of the resting (reference) pattern ( $T = 3.40$  s) used for comparison with the analyzed fragment.

Fig. 9. presents EEG components associated with oculomotor activity in various frequency bands: total (Fig. 9a.), range 0.1 to 4 Hz (Fig. 9v.), and 8 to 14 Hz (Fig. 9c.). Signal filtration revealed predominant activity in the delta band.

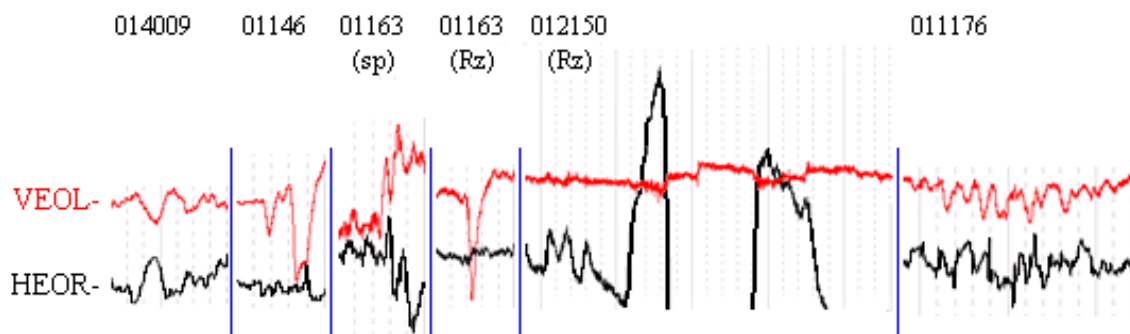


Fig. 5. Examples of EOG activity recorded from VEOG and HEOG derivations.

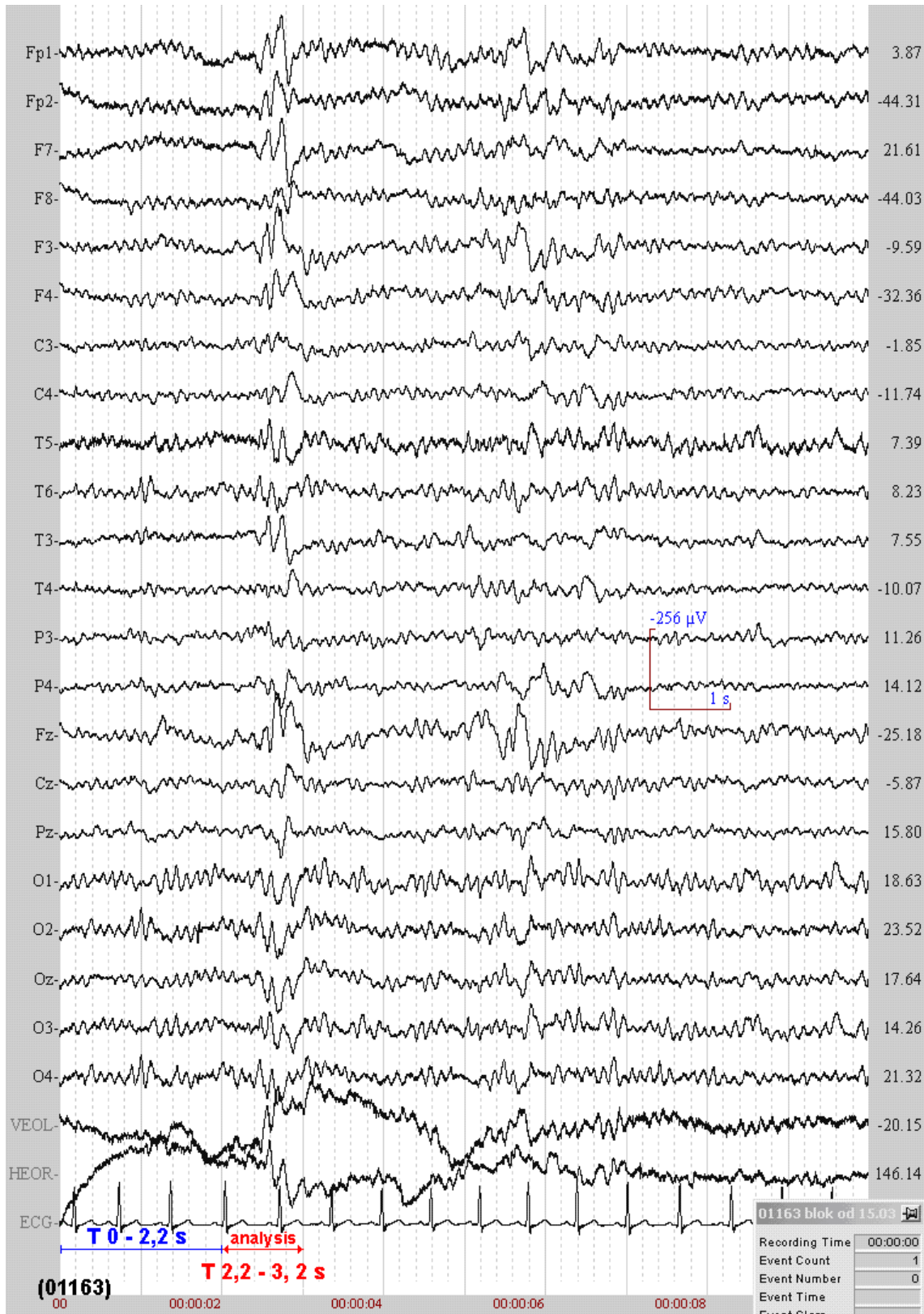


Fig. 6. An example of EEG recording with oculomotor activity monitored in HEOG, VEOG and EEG channels.

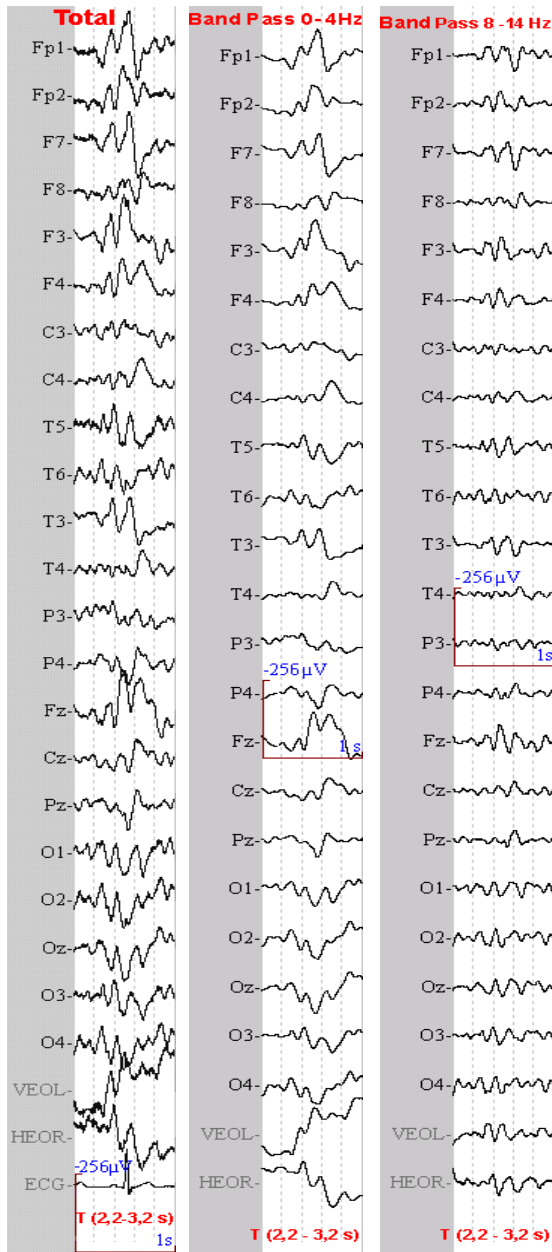


Fig. 6 a.

Fig. 6 b.

Fig. 6 c.

Fig. 6 a-c. Components of EEG signals related to eye movement filtered in frequency bands: b) delta (0-4Hz) and c) alpha 8-14 Hz.

Results of the spectral analysis of the signal within individual regions of brain and frequency bands are shown in Fig. 10. (Group B).

Fig. 10a. (Group B N=10).

Show the differences observed for longer fragments ( $T = 2.8-3.2$  s) in the frontal region for all the analyzed bands. Bands of 0.1-4 Hz, 8-14 Hz, and 0.1-70 Hz (total) featured left-sided predominance, with activity being also observed in the middle (Fz) and motor regions on the right for low frequencies.

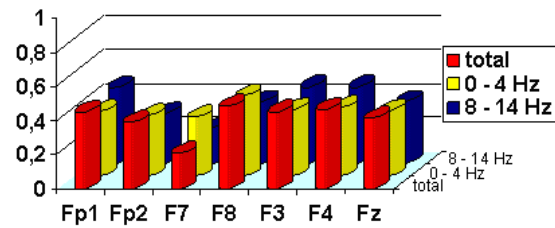


Fig. 7a. The power of spontaneous EEG activity within the frontal region. (Group A N=10)

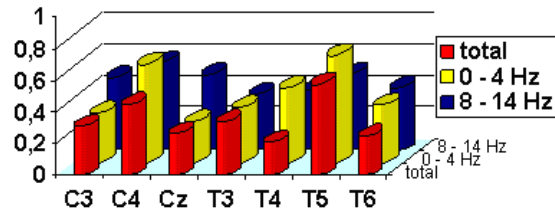


Fig. 7b. The power of spontaneous EEG activity within the middle region. (Group A N=10)

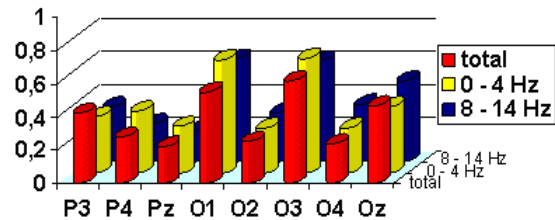


Fig. 7c. The power of spontaneous EEG activity within the occipital region. (Group A N=10)

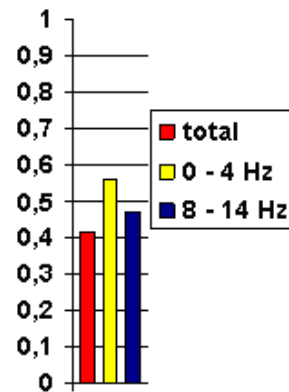


Fig. 7d. Class correlation analysis. (Group A N=10).

In the three frequency bands, the power of the signal was higher in the motor cortex on the right and in the temporal lobes on the left. Fig. 10b. (Group B N=10).

Intra-Class Correlation analysis revealed signal differences in the occipitoparietal region, with signal predominance on the right. Fig. 10c. (Group B N=10).

The chart in Fig. 10d. shows the average values of power of the EEG signal recorded from 22 leads in the frequency bands of 0.1-4 Hz, 8-14 Hz,



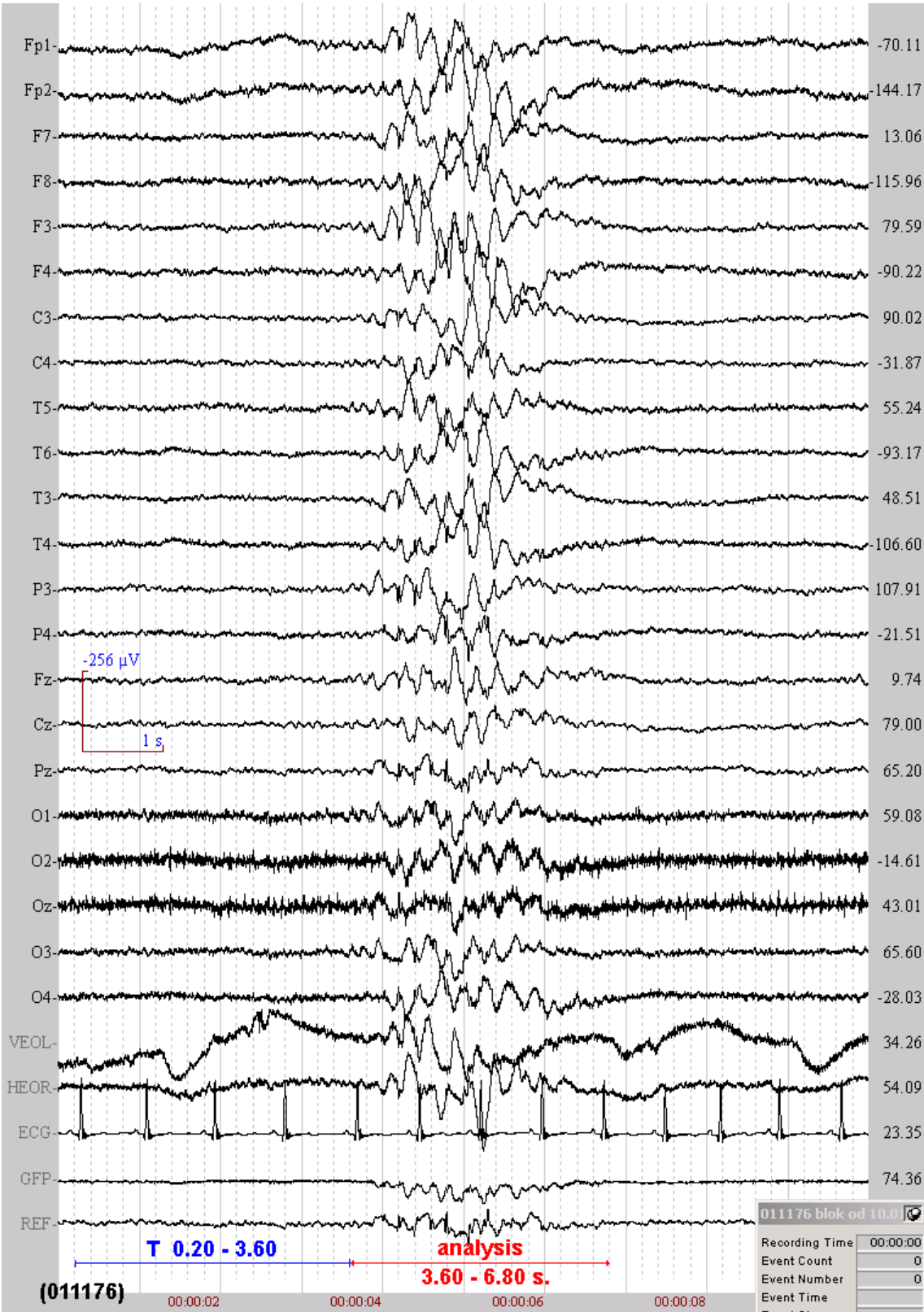


Fig. 8. An example of EEG recording with oculomotor activity monitored in HEOG, VEOG and EEG channels.

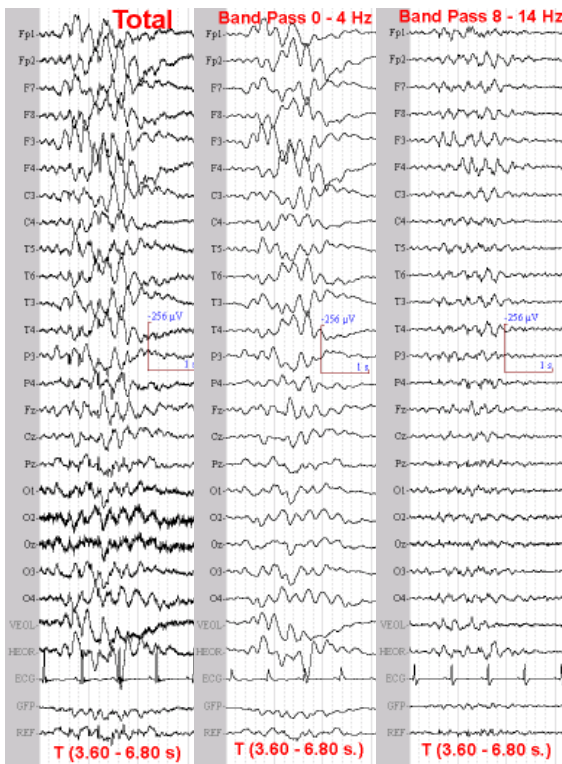


Fig. 9 a.

Fig. 9 b.

Fig. 9 c.

Fig. 9 a-c. Components of EEG signals related to eye movement filtered in frequency bands: b) delta (0-4Hz) and c) alpha (8-14 Hz).

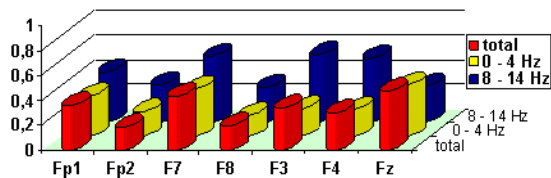


Fig. 10a. Frontal region.

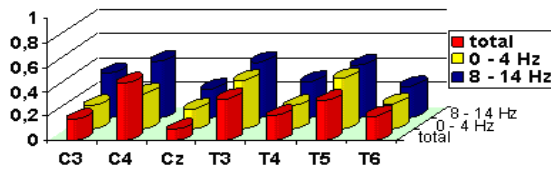


Fig. 10b. Middle region.

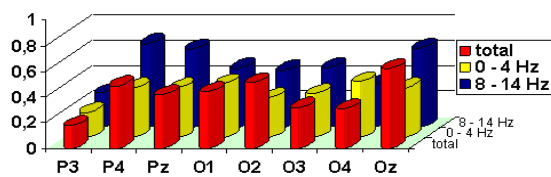


Fig. 10c. Occipital region.

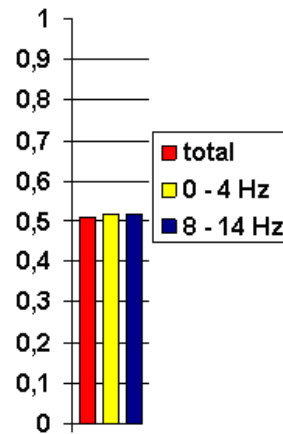


Fig. 10d. Class correlation analysis (N=10).

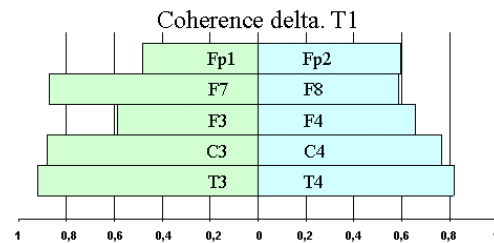


Fig. 11a. Coherence index in resting EEG activity ante neurooculomotor artifacts (T1).

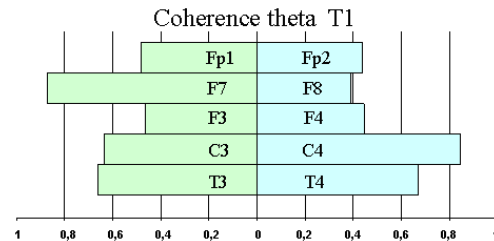


Fig. 11b. Coherence index values in EEG activity during neurooculomotor artifacts (T2).

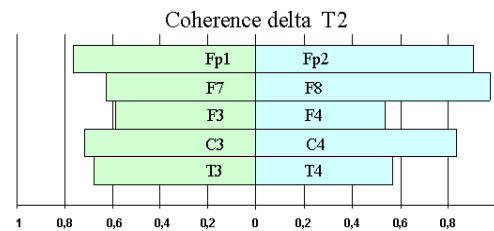
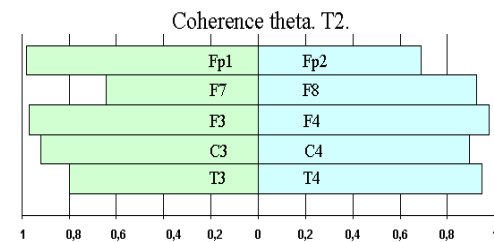


Fig. 11d. Coherence index values in EEG activity during neurooculomotor artifacts (T2).



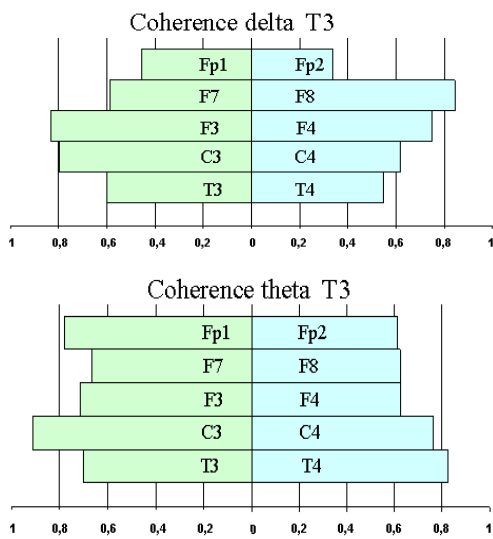


Fig. 11c. Coherence parameters in EEG activity post neurooculomotor artifacts (T3).

Fig. 11. Coherence index during EOG episodes.

and 0.1-70 Hz (total). The mean signal power was similar in all 22 leads and exceeded 50%. One may assume that generalized artifacts of longer durations had no effects on total power in the bands of 0.1-4 Hz, 8-14 Hz, and 0.1-70 Hz. All subjects in the study group (N = 10) were right-handed (random selection).

The highest values of the coherence ratio (as compared to Cz) in Group B (N=10) were observed for EOG artifacts in the theta band (4-8 Hz). In the resting record, the coherence ratio was 0.98 for the frontal region of the left hemisphere compared to 0.68 for the right hemisphere. The lowest values for both hemispheres were observed in the record preceding the episode in the theta band (4-8 Hz) and in the record following the episode in the delta band (0.1-4 Hz).

## DISCUSSION

As shown by the results of our previous studies, records featuring pseudoseizure activity in healthy subjects were characterized by no morphological or amplitude-related differences in activities before and after the episode, as opposed to records obtained from epileptic patients [12]. In the presented study, involving records taken with subjects' eyes being open, instead of shut, another aspects of the record were taken into account, namely the possible relationships between ocu-

lomotor activity and the electrical activity of the brain [5]. In previous studies, we pointed to the differences in EOG signal morphology for spontaneous ocular movements recorded with eyes being shut and open.

Results of the studies of EOG artifacts recorded with eyes being open suggest a possibility of contribution of oculomotor activity in the recorded EEG oscillations. Therefore, interpretation of generalized oscillation episodes in healthy subjects requires the analysis of the morphology and dynamics of oscillation as well as of the simultaneous polyphysiographic EOG activity. Seizure activity was confirmed in two cases; in the remaining case, the observed activity was of pseudoseizure type, as confirmed by the analysis in the theta frequency band.

Thanks to the results of the studies, the procedure for differentiation between seizure and pseudoseizure activity may be complemented, being of much importance for aviation medicine. This importance is due to the fact of pseudoseizure activity being recorded in admission screening examinations in 1.5-2% of candidates. In such cases, qualification results are negative even when subjects present with normal MRI, angioMRI, and fMRI scans. The problem is important due to possible appeals. The social aspect is also important, with young people becoming aware of seizure activity or even diagnosed with epilepsy as the result of examinations. It should be highlighted that the mechanism of origin of pseudoseizure activity remains unknown and may lead to misinterpretations.

Currently, there is a trend in qualification procedures towards narrowing the candidate exclusion criteria associated with the seizure activity presenting as spikes, sharp waves, or spike-and-wave complexes.

## CONCLUSIONS

Differentiation of pseudoseizure and seizure episodes requires oculomotor activity being recorded using an extended protocol with eyes both open and shut in order to verify the impact of oculomotor activity on EEG records.

**AUTHORS' DECLARATION:**

**Study Design:** Jan Miszczak, Stanisław Dec, Ewa Zalewska; **Data Collection:** Jan Miszczak, Stanisław Dec, Ewa Zalewska; **Statistical Analysis:** Jan Miszczak, Stanisław Dec, Ewa Zalewska; **Manuscript Preparation:** Jan Miszczak, Stanisław Dec, Ewa Zalewska; **Funds Collection:** Jan Miszczak, Stanisław Dec, Ewa Zalewska. The Authors declare that there is no conflict of interest.

**REFERENCES**

1. Anderer P, Roberts S, Schlögl A, Gruber G, Klösch G, Herrmann W, Rappelsberger P, Filz O, Barbanj MJ, Dorffner G, Saletu B. Artifact processing in computerized analysis of sleep EEG – a review. *Neuropsychobiology* 1999; 40:150-7.
2. Bennett DR, Duvoisin RC. The EEG in Aerospace Medicine. *Aerosp Med.* 1964; 35:452-8.
3. Blanc C, Lafontaine E, Laplane R. Meaning and Value of Electroencephalography in Aeronautical Medicine. *Aerosp Med.* 1964; 35:249-56.
4. Blanc C, Lafontaine E, Laplane R. Principles and methods of application of electroencephalography in aviation medicine. *Aerosp Med.* 1964; 35:1083-8.
5. Brown M, Marmor M, Vaegan, Zrenner E, Brigell M, Bach M, ISCEV. ISCEV Standard for Clinical Electro-oculography (EOG). *Doc Ophthalmol.* 2006 ;113(3):205-12.
6. Croft RJ, Barry RJ. Removal of ocular artifact from the EEG: a review. *Clin Neurophysiol* 2000; 30(1):5-19.
7. De Clerq W, Vergult A, Vanrumste B, Van Paesschen W, Van Huffel S. Canonical correlation analysis applied to remove muscle artifacts from the electroencephalogram. *IEEE Trans. Biomed. Eng.* 2006; 53(12):2583-7.
8. Dec S, Miszczak J, Zalewska E. Metody weryfikacji padaczkopodobnych zmian w EEG u zdrowych klinicznie pilotów. *Polski Przegląd Medycyny Lotniczej* 2003; (3):307-27.
9. Dec S, Miszczak J, Zalewska E. Rola badań elektroencefalograficznych w przygotowaniu zawodowym pilota. *Polski Przegląd Medycyny Lotniczej* 1998; 4(3):327-43.
10. Gregory RP, Oates T, Merry RT. Electroencephalogram epileptiform abnormalities in candidates for aircrew training. *Electroencephalogr Clin Neurophysiol.* 1993; 86(1):75-7.
11. Hendriksen IJ, Elderson A. The use of EEG in aircrew selection. *Aviat Space Environ Med.* 2001; 72(11):1025-33.
12. Joe-Air Jiang, Chih-Feng Chao, Ming-Jang Chiu, Ren-Guey Lee, Chwan-Lu Tseng, Robert Lin. An automatic analysis method for detecting and eliminating ECG artifacts in EEG. *Computers in Biology and Medicine* 2007; 37(11):1660-71.
13. Joyce CA, Gorodnitsky IF, Kutas M. Automatic removal of eye movement and blink artifacts from EEG data using blind component separation. *Psychophysiology* 2004; 41(2):313-25.
14. Kowalczyk L. Badanie dynamiki aktywności bioelektrycznej mózgu w warunkach stymulacji z zastosowaniem metod oceny podobieństwa sygnałów. Tezy pracy doktorskiej. Warszawa: IBIB PAN; 2006.
15. Leigh JR, Zee DS. The neurology of eye movements. 4th ed. New York (NY): Oxford University Press; 2006.
16. Matsuo F, Peters JF, Reilly EL. Electrical phenomena associated with movements of the eyelid. *Electroenceph Clin Neurophysiol.* 1975; 38(5):507-511.
17. Miszczak J, Dec S, Zalewska E. Significance of EEG variability during suppression reaction for interpretation of EEG performer in pilots with open eyes during activities. *Polski Przegląd Medycyny Lotniczej* 2011; 17(2):145-176.
18. Miszczak J, Zalewska E, Dec S, Kowalczyk L. Badania porównawcze charakterystyki epizodów czynności napadowej rejestrowanych w zapisach EEG klinicznie zdrowych kandydatów do lotnictwa i osób chorych na padaczkę. *Polski Przegląd Medycyny Lotniczej.* 2010; 16(2):113-129.
19. Picton TW, von Roon P, Armillo ML, Berg P, Ille N, Scherg M. The correction of ocular artifacts: a topographic perspective. *Clin Neurophysiol* 2000; 111(1):53-65.
20. Sobieszek A. Problemy identyfikacji i kwalifikacji zjawisk o charakterze napadowym występujących we wzorze czynności bioelektrycznej ośrodkowego układu nerwowego. *Przegląd Lekarski* 2010; 67(9): 745-49.
21. Sobieszek A. Wzory zapisu EEG o charakterze napadowym. *Postępy Nauk Medycznych* vol. XXVI 2013; 10:683-90.
22. Stone J, Campbell K, Sharma N, Carson A, Warlow CP, Sharpe M. What should we call pseudoseizures? The patient's perspective. *Seizure* 2003; 12(8):568-72.
23. van Vugt MK, Sederberg PB, Kahana MJ. Comparison of spectral analysis methods for characterizing brain oscillations. *J Neurosci Methods.* 2007 15;162(1-2):49-63.

**Cite this article as:** Miszczak J, Dec S, Zalewska E. Analysis of Relationship Between Oculomotor and Pseudoseizure Activity in EEG Examinations of Aviation Personnel. *Pol J Aviat Med Psychol* 2014; 20(2):5-16. DOI: 10.13174/pjamp.20.02.2014.1